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(71)(72) Applicants and Inventors: SUNAY, Oguz [TR/US]; 8019 North MacArthur Boulevard, #1077, Irving, TX 75063 (US). LE, Khiem [US/US]; 607 St. Andrews Place, Coppell, TX 75019 (US).

(74) Agent: LYNCH, David, W.; 10749 Bren Road East, Minneapolis, MN 55343 (US).

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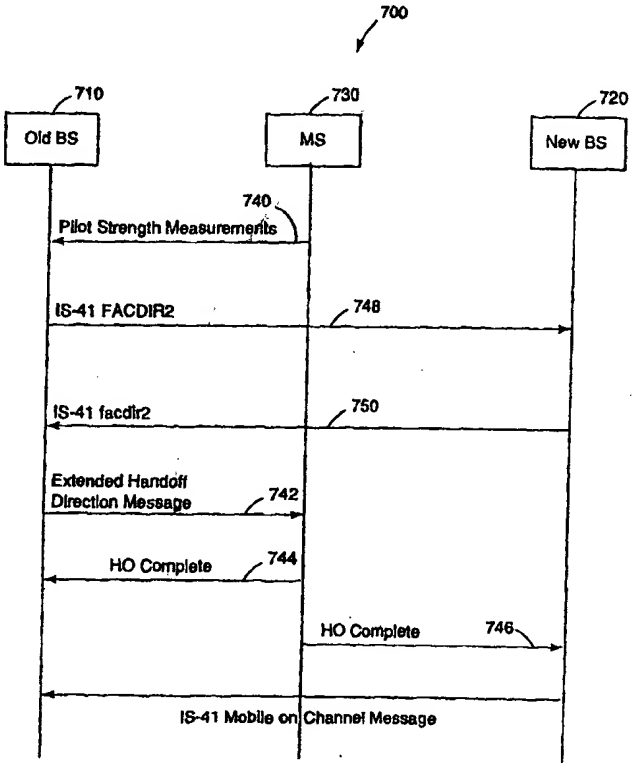
(54) Title: METHOD AND APPARATUS FOR PROVIDING BASE STATION INFORMATION FOR A MOBILE DURING HAND-OFFS

(57) Abstract

A method and apparatus for providing active set information for a mobile to provide seamless interworking during hard handoffs is disclosed. This is accomplished by providing active set data in the facdir2 return message during the handoff procedure. The handoff method includes the steps of sending to the old base station quality and received signal strength measurements gathered by the mobile station, sending from the old base station to the new base station a message to invoke negotiations between the old base station and the new base station, sending from the new base station to the old base station a return message, the return message including an active set information for the new base station, providing by the old base station the active set information for the new base station and directing the mobile station to perform a handoff to the new base station, performing the handoff to the new base station by the mobile station and indicating to the old base station and the new base station by the mobile station the completion of the handoff and notifying the old base station that the mobile station has moved to the new base station.



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METHODS AND APPARATUS FOR PROVIDING BASE STATION INFORMATION FOR A MOBILE DURING HANDOFFS

BACKGROUND OF THE INVENTION

1. Field of the Invention.

This invention relates in general to a mobile communications, and more particularly to a method and apparatus for providing active set information for a mobile to provide seamless interworking during hard handoffs.

2. Description of Related Art.

The demand by consumers all over the world for mobile communications continues to expand at a rapid pace and will continue to do so for at least the next decade. Over 100 million people were using a mobile service by the end of 1995, and that number is expected to grow to 300 million by the year 2000. Several factors are contributing to the exciting growth in the telecommunications industry. For example, a combination of technology and competition bring more value to consumers. Phones are smaller, lighter, had a longer battery life, and are affordable now for the mass market. Operators are providing excellent voice quality, innovative services, and roaming across the country or world. Most important, mobility is becoming less expensive for people to use. Around the world, as well as in the United States, governments are licensing additional spectrum for new operators to compete with traditional cellular operators. Competition brings innovation, new services, and lower prices for consumers.

Fig. 1 illustrates a basic, generic wireless telecommunication system 100. This system can be broken down to blocks as shown in Fig. 1. The human voice fed to the microphone of a handset 110 is transmitted through the atmosphere 112 to the base station 114. From the base station 114, the signal is routed to a switching center 116 or rebroadcast 118. Similarly, at the network end the voice information is transmitted from the base station 120 and received by the handset 122. Each handset 110, 112 and base station 114, 120 have the transmitter/receiver (transceiver) function.

Prior to the cellular concept, the approach to providing mobile services was similar to the approach taken by radio and television stations. The operators set up huge transmitters at the highest point in a geographic area. Then they sent high-powered transmissions resulting in a large coverage area. The consequence of this was twofold: 1) there was a capacity problem; and 2) the mobile stations consumed a large amount of power. Therefore, the mobile stations were very bulky and expensive.

The solution to this problem is to decrease the power of transmission, thereby reducing the coverage area of the transmitter. Because the range of each area is small, a large area may be divided into several smaller areas called cells. Each cell may have its own antenna, a set of frequencies, and transmitter/receiver radio units.

Accordingly, in cellular networks, unlike in the old mobile architecture, there were multiple cells covering an area. Hence, calls had to be passed as the vehicle or mobile unit moved from one cell to another. This is called handoff. Fig. 2 illustrates this handoff process. As a vehicle 210 moved away from base station

212, its signal strength decreases. The base station 212 monitored the signal strength during the duration of the call. When signal strength fell below a predetermined threshold level the network 214 asked all predetermined candidates neighboring cells 220 to report the signal strength of the mobile in the vehicle 210. If the signal strength in the neighboring cell 220 was stronger by a predetermined amount, then the network 214 attempted to handoff the call to the candidate neighboring cell 220. Today the cellular system refers to these three basic elements as a mobile station 210, cell sites 202, 220 and mobile switching centers. These three elements are integrated to form a ubiquitous coverage radio system that can connect to the public switched telephone network 240.

There are several types of cellular systems throughout the world. One such system in the United States is the code division multiple access (CDMA) system, which is based on the IS-95 industry specification. IS-95 CDMA combines new digital spread spectrum CDMA and advanced mobile phone service (AMPS) functionality into one dual-mode cellular telephone on the 800 MHz band, and can use a CDMA-only handset on the 1.9 GHz PCS band.

CDMA systems primarily differ from FDMA (Analog) and TDMA systems through the use of coded radio channels. In a CDMA system, users can operate on the same radio channel simultaneously by using different coded sequences.

IS-95 CDMA cellular systems have several key attributes that are different from other cellular systems. The same CDMA radio carrier frequencies may be optionally used in adjacent cell sites, which eliminates the need for frequency planning, the wide band radio channel provides less severe fading, which results in more consistent quality voice transmission under varying radio signal conditions.

The initial IS-41 standards address basic wireless intersystem function such as basic intersystem handoff, basic service qualification and basic OA&M (circuit management). Basic intersystem handoff included the core functions still used today. For example, handoff measurements, handoff forward, handoff back, and inter-mobile switching center trunk release were all supported. Following the initial IS-41 standard, IS-41-A addressed intersystem handoff, enhanced service qualification, location management, mobile station state management, call delivery, and cellular feature support. Intersystem handoff was essentially the same as in the initial IS-41 standard except for some minor modifications to the handoff procedures, and the use of ANSI Transaction Capability Application Port (TCAP) as the transaction protocol. This application protocol was specified for use over X.25, as the primary choice, or North American SS7, as the second choice. Further, IS-41-A supports the first group of cellular features to enhance subscriber service such as call forwarding, call waiting, three-way calling and feature control.

IS-41-B was published in December 1991 and addressed path minimization, flash feature support after handoff, support for TDMA handoff parameters, and use of SS7 Global Title translation. Within 3 years within the publication of IS-41-B, several telecommunications system bulletins (TSBs) were published to add enhancements or correct problems with both IS-41-A and IS-41-B.

IS-41-C was published in February 1996 and is the culmination of hundreds of person-years of effort. IS-41-C is a major rework of the entire standard. The motivation to revise the IS-41 standard was a desire to provide many more features and services to mobile subscribers, to resolve compatibility problems found in earlier revisions of IS-41, to integrate the TSBs into a single standard specification

and a desire to incorporate state-of-the-art technology such as intelligent networking principles and philosophies. The initial version of IS-41 was primarily in intersystem handoff standard. While automatic roaming now accounts for the majority of IS-41-C operations, intersystem handoff remains an important part of the IS-41 standard. Handoff encompasses a set of mobile stations (MS) functions and network functions enable an MS to move from one radio channel to another radio channel while a call is in progress.

Fig. 3 illustrates two categories of handoffs 300. Intrasystem handoff 310 and Intersystem handoff 350 are the two types of handoffs. Intrasystem handoff is a handoff between two radio channels or base stations 312, 314 that are controlled by the same mobile switching center (MSC) 320. No coordination is required between MSC's to support intrasystem handoff; therefore, intrasystem handoff is not within the scope of IS-41. Intersystem handoff 350 involves a handoff between two radio channels or base stations 352, 354 that are controlled by two different MSC's 360, 370. This type of handoff requires specialized signaling between two MSC's 360, 370 to coordinate the movement of the mobile station between the two base stations 352, 354.

In particular regard to CDMA to CDMA hard handoff, the base station directs the mobile station by sending an "Extended Handoff Direction Message." As described in the IS-95 standard, the "Extended Handoff Direction Message" includes information on the new CDMA signaling frequency and the corresponding Active Set for this frequency band. The Active Set information includes the base station specific pilot PN offset, power control symbol and the Walsh code channel that is available for trafficking. The IS-41 standard specifies the inter-system signaling

protocol for a number of air interface standards such as IS-95 and IS-136. However, currently, this standard does not specify the transfer of any Active Set information between the old and the new base stations during a handoff.

It can be seen that there is a need for a method for hard handoffs that provides Active Set information between old and new base stations.

It can also be seen that there is a need for a method for hard handoffs that provides seamless interworking of IS-41 and IS-95.

SUMMARY OF THE INVENTION

To overcome the limitations in the prior art described above, and to overcome other limitations that will become apparent upon reading and understanding the present specification, the present invention discloses a method and apparatus for providing active set information for a mobile to provide seamless interworking during hard handoffs.

The present invention solves the above-described problems by providing active set data in the facdir2 return message during the handoff procedure..

A method in accordance with the principles of the present invention includes the steps of sending to the old base station quality and received signal strength measurements gathered by the mobile station, sending from the old base station to the new base station a message to invoke negotiations between the old base station and the new base station, sending from the new base station to the old base station a return message, the return message including an active set of information for the new base station, providing by the old base station the active information for the new base station and directing the mobile station to perform a handoff to the new base station, performing the handoff to the new base station by the mobile station and indicating to the old base station and the new base station by the mobile station the completion of the handoff and notifying the old base station that the mobile station has moved to the new base station.

Other embodiments of a system in accordance with the principles of the invention may include alternative or optional additional aspects. One such aspect of the present invention is that the active set data further includes a pilot PN offset for the

These and various other advantages and features of novelty which characterize the invention are pointed out with particularity in the claims annexed hereto and form a part hereof. However, for a better understanding of the invention, its advantages, and the objects obtained by its use, reference should be made to the drawings which form a further part hereof, and to accompanying descriptive matter, in which there are illustrated and described specific examples of an apparatus in accordance with the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Referring now to the drawings in which like reference numbers represent corresponding parts throughout:

Fig. 1 illustrates a basic, generic wireless telecommunication system;

Fig. 2 illustrates a handoff process where calls are passed as the vehicle or mobile unit moves from one cell to another;

Fig. 3 illustrates intrasystem and intersystem handoffs;

Fig. 4 illustrates a diagram of an IS-95 CDMA system;

Fig. 5 shows a table illustrating the types of handoffs specified by IS-95;

Fig. 6 is a table illustrating the types of information tracked by the mobile during handoffs; and

Fig. 7 illustrates CDMA to CDMA hard handoff 700 according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

In the following description of the exemplary embodiment, reference is made to the accompanying drawings which form a part hereof, and in which is shown by way of illustration the specific embodiment in which the invention may be practiced. It is to be understood that other embodiments may be utilized as structural changes may be made without departing from the scope of the present invention.

The present invention provides seamless inter-working of the network and air interface signaling protocols, namely, IS-41 and IS-95. For this purpose, the 'facdir2" message within IS-41 is modified to include information on the Active Set for the mobile when it handoffs to the target BS.

Fig. 4 illustrates a diagram of an IS-95 CDMA system 400. The IS-95 CDMA system 400 allows for voice or data communications on a IS-95 CDMA radio channel 410 via either a 30 kHz AMPS radio channel 412 (when used on the 800 MHz cellular band) or a relatively new 1.23 MHz CDMA radio channel 414. As shown in Fig. 4, the IS-95 CDMA radio channel 410 allows multiple mobile telephones to communicate on the same frequency at the same time by special coding of their radio signals. The IS-95 CDMA system includes many of the same basic subsystems as other cellular systems, including a switching network 420, base stations (BS) 422, and mobile telephones 430. IS-95 systems can serve mobile telephones of three types: AMPS only 432, IS-95 Dual Mode 434 or IS-95 (digital only) 436.

The IS-95 CDMA cellular system 400 has several key attributes that are different from other cellular systems. The same frequencies of the CDMA radio carrier 410 may be optionally used in adjacent cell sites, which eliminates the need

for frequency planning, and the wide-band radio channel 410 provides less severe fading, which results in more consistent quality voice transmission under varying radio signal conditions.

In addition, the IS -95 standard supports three types of handoffs while in the Mobile Station Control on the Traffic Channel State. Fig. 5 shows a table 500 illustrating the types of handoffs specified by IS-95. The first type of handoff is a soft handoff 510. A soft handoff is a handoff in which the mobile station commences communications with a new base station without interrupting communications with the old base station. Soft handoff can only be used between CDMA channels having identical frequency assignments. Soft handoff provides diversity of Forward Traffic Channels and Reverse Traffic Channel paths on the boundaries between base stations.

The second type of handoff is a CDMA to CDMA Hard Handoff 520. A CDMA to CDMA Hard Handoff 520 is a handoff in which the mobile station is transitioned between disjoint sets of base stations, different frequency assignments or different frame offsets. Finally, there is a CDMA to Analog Handoff 530. A CDMA to Analog Handoff 530 is a handoff in which the mobile station is directed from a Forward Traffic Channel to an analog voice channel.

The mobile must also keep track of several types of information in order to perform handoffs. Fig. 6 is a table illustrating the types of information tracked by the mobile. The first set of information is the Active Set 610. The Active Set 610 is the pilots associated with the Forward Traffic Channels currently assigned to the mobile station. The second set of information is the candidate set 620. The candidate set 620 is the pilots that are not currently in the Active Set but have been

Thus, upon receiving the "Pilot Strength Measurement Message" 740 the old base station starts negotiating with the new, target base station 720 for service. For this purpose, the old base station sends a "FACDIR2" message 748. If the new base station 720 can accommodate the mobile 730, the new base station 720 sends a facdir2" return result message 750. For seamless inter-working of the 1S-41 with 1S-95, the new base station sends the Active Set information to the old base station 710 in the "facdir2" return message 750. The "facdir2" return message 750 already includes information on the PN Code Offset, Band Class, CDMA Channel Number of the new base station 720. This information is then forwarded by the old base station 710 to the mobile 730 via the "Extended Handoff Direction Message" 742. Also included in this message is information on the Forward Traffic Channel that the new base station 720 can allocate for the mobile 730. The "Extended Handoff Direction Message" 742 contains the information on the new Active Set received by the old base station 710 from the new base station 720. As mentioned above, the Active Set data is provided to the old base station 710 according to the present invention via the "facdir2" message. The Active Set information is the base station specific pilot PN offset, power control symbol and the Walsh code channel that is available for trafficking.

In summary, seamless inter-working of the network and air interface signaling protocols, namely, IS-41 and 1S-95, is provided. To accomplish this, the 'facdir2" message within IS-41 is modified to include information on the Active Set for the mobile when it handoffs to the new base station. Thus, the method provides Active Set information between old and new base stations to allow seamless interworking of IS-41 and IS-95.

The foregoing description of the exemplary embodiment of the invention has been presented for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed. Many modifications and variations are possible in light of the above teaching. It is intended that the scope of the invention be limited not with this detailed description, but rather by the claims appended hereto.

WHAT IS CLAIMED IS:

1. A method for providing active set information enabling a mobile to provide seamless interworking during hard handoffs between an old and a new base station, comprising the steps of:

sending to the old base station quality and received signal strength measurements gathered by the mobile station;

sending from the old base station to the new base station a message to invoke negotiations between the old base station and the new base station;

sending from the new base station to the old base station a return message, the return message including an active set of information for the new base station;

providing by the old base station the active set information for the new base station and directing the mobile station to perform a handoff to the new base station;

performing the handoff to the new base station by the mobile station and indicating to the old base station and the new base station by the mobile station the completion of the handoff; and

notifying the old base station that the mobile station has moved to the new base station.

2. The method of claim 1 wherein the active set information further comprises a pilot PN offset for the new base station, a power control symbol and a Walsh code channel that is available for trafficking.

3. The method of claim 1 wherein the step of sending to the old base station quality and received signal strength measurements gathered by the mobile station further comprises the step of sending the old base station pilot strength measurements.

4. The method of claim 3 wherein the pilot strength measurements further comprise information for the mobile to derive a time reference for a PN sequence.

5. The method of claim 1 wherein the step of sending from the old base station to the new base station a message to invoke negotiations between the old base station and the new base station further comprises the step of sending a FACDIR2 message to the new base station.

6. The method of claim 1 wherein the step of sending from the new base station to the old base station a return message further comprises the step of including the active set of information for the new base station in a facdir2 message.

7. The method of claim 6 wherein the facdir2 message further comprises information on the PN Code Offset, Band Class, CDMA Channel Number of the new base station, the Forward Traffic Channel that the new base station can allocate for the mobile station.

8. The method of claim 1 wherein the step of providing by the old base station the active set information for the new base station and directing the mobile station to perform a handoff to the new base station further comprises the step of issuing an Extended Handoff Direction Message to the mobile station.

9. The method of claim 8 wherein the Extended Handoff Direction Message further comprises an action time indicating when the mobile station is to disables a transmitter, resets a fade timer, suspends incrementing TOT_FRAMES and BAD_FRAMES counters and tune to the assigned Forward Traffic Channel.

10. The method of claim 9 further comprising the step of re-enabling the transmitter of mobile station and resume incrementing the TOT_FRAMES and BAD_FRAMES counters upon receiving a sufficiently large number of good frames on an assigned Forward Traffic Channel.

11. The method of claim 8 further comprises the step of performing by the mobile station acquisition of pilots in the Active Set specified by the Extended Handoff Direction Message.

12. The method of claim 1 wherein the step of notifying the old base station that the mobile station has moved to the new base station further comprises the step of issuing from the new base station an IS-41 MobileOnChannel message.

13. The method of claim 1 further comprises the step of determining whether a set of pilots in an Active Set, Candidate Set or a Neighbor set has been altered before sending to the old base station quality and received signal strength measurements gathered by the mobile station.

14. The method of claim 13 wherein the step of determining whether a set of pilots in an Active Set, Candidate Set or a Neighbor set has been altered further comprises the steps of:

determining whether a strength of a Neighbor Set or Remaining Set pilot is above a predetermined threshold;

detecting whether a strength of a Candidate Set pilot exceeds a strength of an Active Set pilot by a predetermined amount;

identifying when a handoff drop timer of an Active Set pilot expires; and

monitoring when the old base station sends a Pilot Measurement Request Order Message.

15. A method for providing active set information enabling a mobile to provide seamless interworking during hard handoffs between an old and a new base station, comprising the steps of:

sending a Pilot Strength Measurement Message from the mobile to the old base station;

in response to receipt of the Pilot Strength Measurement Message, sending a IS-41 FACDIR2 message from the old base station to the new base station to initiate negotiation for service with the new base station;

responding to the IS-41 FACDIR2 message by returning a IS-41 facdir2 message from the new base station to the old base station, the IS-41 facdir2 message including active set information therein;

instructing the mobile station to perform the CDMA to CDMA hard handoff by sending form the old base station to the mobile station an Extended Handoff Direction Message;

indicating the completion of the handoff by sending from the mobile station to the new and old base stations a Handoff Completion message; and

notifying the old base station that the mobile station has moved to the new base station by issuing from the new base station to the old base station an IS-41 MobileOnChannel message.

16. A cellular communications system comprising a mobile station, an old base station and a new base station, wherein a seamless hard handoff between the old base station and new base station for the mobile station is provided by including active set data for the new base station to the old base station via a facilities directive return message.

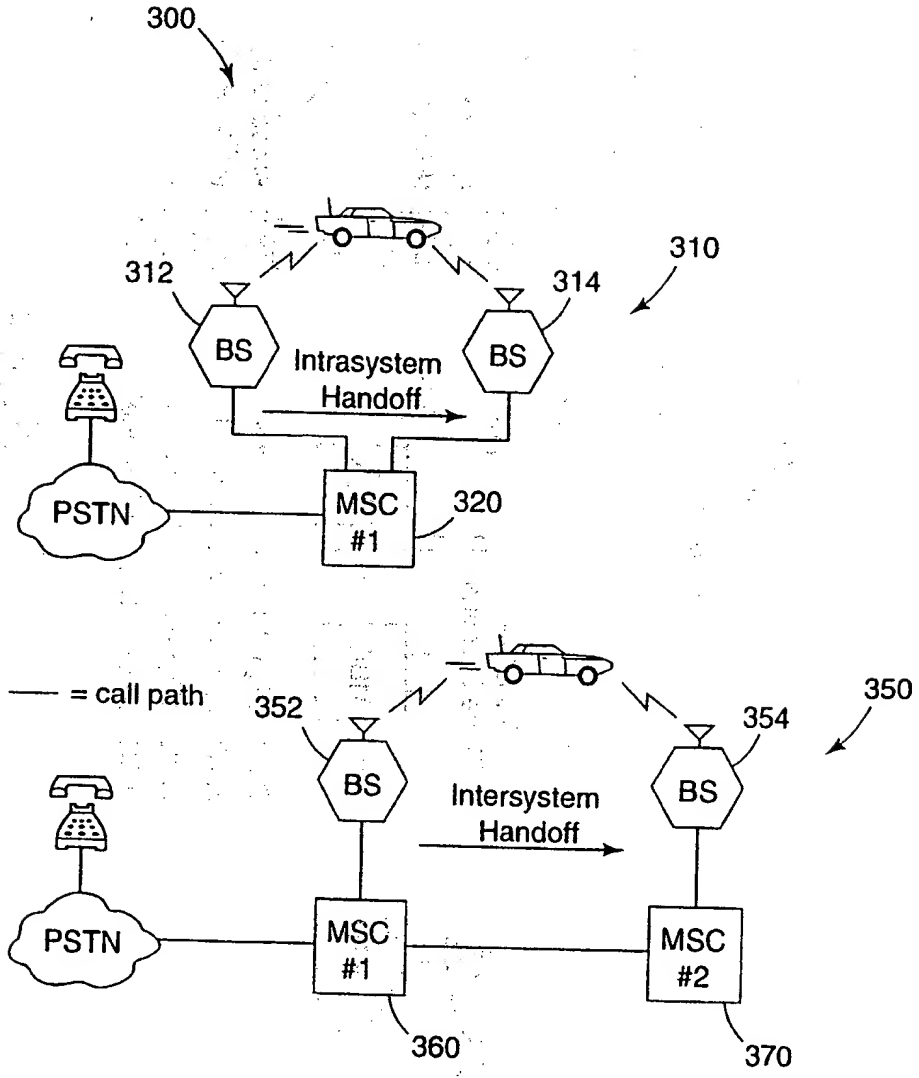
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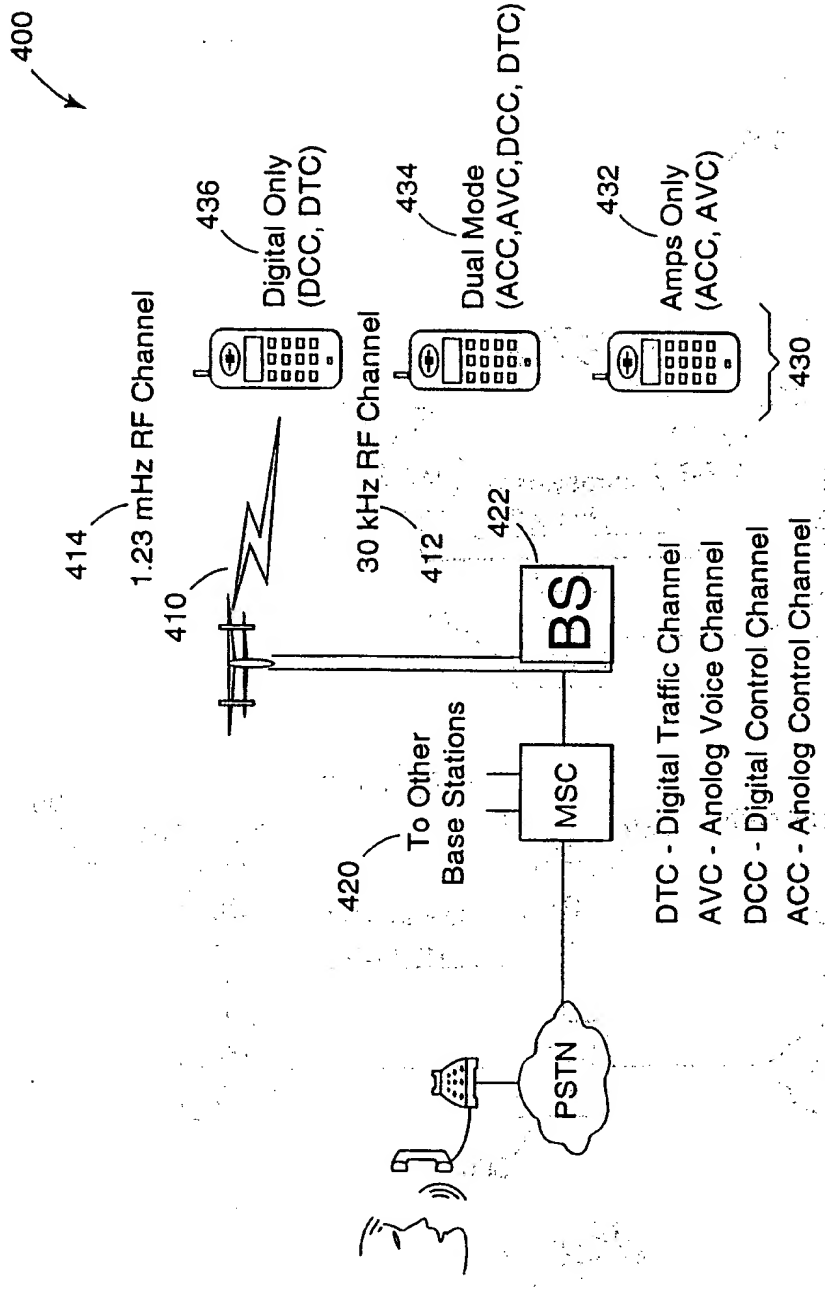
Fig. 3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410
30 kHz RF Channel
412
422
BS
MSC
420
To Other
Base Stations
PSTN
436
Digital Only
(DCC, DTC)
434
Dual Mode
(ACC,AVC,DCC, DTC)
432
Amps Only
(ACC, AVC)
430
DTC - Digital Traffic Channel
AVC - Anolog Voice Channel
DCC - Digital Control Channel
ACC - Anolog Control Channel

Fig. 4

INTERNATIONAL SEARCH REPORT

Inte onal Application No
PCT/US 99/21905

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04Q7/38

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04Q H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	HOLCMAN A R ET AL: "CDMA INTERSYSTEM OPERATIONS" PROCEEDINGS OF THE VEHICULAR TECHNOLOGY CONFERENCE,US,NEW YORK, IEEE, vol. CONF. 44, 8 - 10 June 1994, page 590-594, XP000496745 page 591, left-hand column, line 14 -right-hand column, line 14 --- -/--	1-8, 11-13, 15,16

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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Date of the actual completion of the international search	Date of mailing of the international search report
12 January 2000	19/01/2000

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

Inte onal Application No
PCT/US 99/21905

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 761 623 A (LUPIEN FRANCIS ET AL) 2 June 1998 (1998-06-02) column 2, line 29 - line 45 column 4, line 25 - line 38 column 5, line 53 -column 6, line 6 column 7, line 42 - line 60 column 8, line 4 - line 11 column 8, line 47 - line 59 column 14, line 1 - line 11 column 14, line 37 - line 46 column 15, line 56 -column 16, line 6 -----	1-3,5-7, 12,16

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inte ional Application No
PCT/US 99/21905

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